**DEPARTMENT OF HEALTH SERVICES**
DIVISION OF DRINKING WATER AND ENVIRNOMENTAL MANAGEMENT
TECHNICAL OPERATIONS SECTION
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# STATE OF CALIFORNIA
# DIVISION OF DRINKING WATER
# AND
# ENVIRONMENTAL MANAGEMENT

# TREATMENT TECHNOLOGY REPORT
# FOR
# RECYCLED WATER

## April 2003

This document has been developed to serve as a reference source for those seeking information concerning technologies that have been recognized by the California State Department of Health Services (CDHS) as being acceptable for compliance with treatment requirements of the California Recycled Water Criteria. This is a "living" document that will be updated periodically as needed. Readers who find errors or omissions should contact Jeff Stone of the SDHS Recycled Water Unit at jstone1@dhs.ca.gov.

**STATE OF CALIFORNIA**
**DEPARTMENT OF HEALTH SERVICES**
**DIVISION OF DRINKING WATER**
**AND**
**ENVIRONMENTAL MANAGEMENT**

# TREATMENT TECHNOLOGY REPORT FOR RECYCLED WATER

**April 2003**

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# State of California
# Department of Health Services
# Division of Drinking Water

# Treatment Technology Report for Recycled Water

April 2003

## 1. INTRODUCTION

The purpose of this document is to provide general reference information concerning those treatment technologies that are being utilized for meeting the filtration performance and disinfection requirements for compliance with the California Recycled Water Criteria (Title 22, et. seq.). The information contained herein was generated from a review of files and correspondence of the California State Department of Health Services (CDHS), and discussions with Field Operations Branch District Staff, SWRCB Staff, industry representatives and manufacturers. All referenced reports, letters and other documents are on file with the Department's Recycled Water Unit. This reference document may not reflect all treatment technologies in place in California, but will be updated as additional information is obtained.

The California Water Recycling Criteria (adopted December 2000) define Disinfected Tertiary Recycled Water as a wastewater, which has been oxidized and meets the following:

A. Has been coagulated* and passed through natural undisturbed soils or a bed of filter media pursuant to the following:

   1. At a rate that does not exceed 5 GPM/$ft^2$ in mono, dual or mixed media gravity or pressure filtration systems, or does not exceed 2 GPM/$ft^2$ in traveling bridge automatic backwash filters; and

   2. The turbidity does not exceed any of the following; a daily average of 2 NTU, 5 NTU more than 5% of the time within a 24-hour period, and 10 NTU at any time.

*Note: Coagulation may be waived if the filter effluent does not exceed 2 NTU, the filter influent is continuously measured, the filter influent turbidity does not exceed 5 NTU, and automatically activated chemical addition or diversion facilities are provided in the event filter effluent turbidity exceeds 5 NTU.

OR

B. Has been passed through a micro., nano., or R.O. membrane following which the turbidity does not exceed any of the following: 0.2 NTU more than 5% of the time within a 24-hour period and 0.5 NTU at any time.

AND

C. Has been disinfected by either:

1. A chlorine disinfection process that provides a CT of 450 mg-min/l with a modal contact time of not less than 90 minutes based on peak dry weather flow, or

2. A disinfection process that, when combined with filtration, has been demonstrated to achieve 5-log inactivation of virus.

## 2. GENERAL GUIDANCE

The following guidance is consistent with the Water Recycling Criteria and will serve as the basis for CDHS review and acceptance of treatment technologies for compliance with the filtration and disinfection requirements of the Criteria.

FILTRATION

Filters meeting the definition of "filtered wastewater" under Section 60301.320 (a&b) and those demonstrating equivalency under Section 60320.5 ("Other Methods of Treatment") outlined in the Water Recycling Criteria are allowed the option of either disinfection approach outlined in Section 60301.230 without additional restrictions or requirements.

The Department considers a properly filtered and disinfected recycled water meeting the turbidity performance and coliform requirements outlined in the criteria to be essentially pathogen free. As noted by Asano et al.[(1)], "To achieve efficient virus removal or inactivation in tertiary treatment, two major criteria must be met: 1) the effluent must be low in suspended solids and turbidity prior to disinfection to prevent shielding of viruses and chlorine demand, and 2) sufficient disinfectant must be applied to the wastewater." Treatment requirements determined necessary to meet the disinfected tertiary – 2.2 criteria outlined in the Criteria include media filtration to reduce turbidity to less than a daily average of 2 NTU or membrane filtration to reduce turbidity to less than a daily average of 0.2 NTU, and disinfection to ensure a minimum CT of 450 milligram-minutes per liter at all times. This treatment

scheme is intended to remove solids (including some pathogens) and properly prepare the water for effective disinfection in order to achieve an approximately five-log reduction of virus.

However, with respect to many existing technologies, there has yet to be a demonstrated correlation between turbidity and pathogen concentration. The current turbidity performance standards for media and membrane filtration are based on achievable turbidity performance and do not assure any specific minimum level of pathogen removal. This is a recognized issue in the regulations that needs to be addressed by the Department and the water recycling industry.

Since the Pomona Virus Study[2], biological treatment has introduced additional variables into the picture, as the type of biological treatment can impact the particle size distribution and downstream filter and disinfection performance. However, the integration of these processes, into a process train, are not well understood at this time and must be addressed by industry and regulators. Nevertheless, it remains the intent of the Department to produce an essentially pathogen free effluent by maintaining a 5-log virus removal/inactivation barrier through filtration and disinfection.

Additional information concerning treatment technologies may be found in Appendix A (California Department of Health Services-Reduction of Virus and Bacteria by Filtration and Disinfection, October 2001).

It must be recognized that the Title 22 filtration performance requirements, as outlined under Section 60301.320, must be reliably met by all filtration technologies. It is suggested that recycled water producers develop and implement plant performance optimization plans and make a reasonable effort to minimize effluent turbidity levels. Furthermore, all treatment facilities should be operated in accordance with the manufacturer’s recommendations and specific conditions of approval developed by CDHS.

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1. Asano, T.; Tchobanoglous, G.; and Cooper, R.C (1984), "Significance of Coagulation-Flocculation and Filtration Operations in Wastewater Reclamation and reuse", in Symposium Proceedings, The Future of Water Reuse, Water Reuse Symposium III, San Diego, California, August 26-31, 1984. American Waterworks Association Research Foundation.

2. County Sanitation Districts of Los Angeles County (1977), “Pomona Virus Study, Final Report”, Prepared for Calif. State Water Resources Control Board, Sacramento, Calif., and USEPA, Washington, D.C

UV DISINFECTION

*UV Disinfection Guidelines* were published in 1993 by the National Water Research Institute (NWRI). Since that time, the field of ultraviolet disinfection has taken great strides forward. As a result of the progress made in understanding the UV disinfection process, the CDHS and the NWRI agreed that it was time to revise and update the guidelines. NWRI and the American Water Works Association Research Foundation (AWWARF) pooled their resources in order to revise the current guidelines, which now cover water recycling and drinking water UV disinfection applications. As a result of these efforts the *"Ultraviolet Disinfection Guidelines for Drinking Water and Water Reuse"* were published by NWRI/AWWARF in December 2000. CDHS endorses these Guidelines and refers to them when evaluating UV disinfection proposals. One major recommendation of the guidelines is that all UV equipment (including previously approved equipment) be tested and validated under these new guidelines before being accepted by the Department. It is believed that existing UV disinfection systems that were properly designed should comply with the elements of the revised guidelines.

The implication of the recommendations contained in the revised guidelines is that even the horizontal low-pressure low intensity UV systems must be validated before they are accepted for a UV disinfection application. Previously accepted UV technologies that were considered to be nonconforming under the 1993 guidelines will also have to be retested using the recommended testing procedure. The UV technologies listed herein include a note indicating whether compliance with the December 2000 guidelines has been demonstrated by the manufacturer.

Agencies that are in the stages of planning or early design have the most flexibility and should be able to require completion of UV validation testing before they accept delivery of the UV equipment. Therefore, the agency can plan and begin the design work around a given UV system, but not allow delivery of equipment until validation testing is completed. This will allow comparison of the UV reactor design to the validation test results in order to ensure adequate sizing and performance of the UV system. This could be done as part of design review process, i.e., while the design is not yet complete.

If the design process has been completed and the contract for equipment has been signed, there will be fewer recourses for the utility. However, the utility can require a demonstration of

performance or performance guarantee on the equipment for their own protection.

It is important to note that these are only “guidelines” and are therefore not limiting with respect to alternative approaches a manufacturer or project proponent may propose for consideration on a case-by-case basis. It is possible however that future regulations may be based on these guidelines.

(Continued on next page)

# 3. FILTRATION TECHNOLOGIES

## Granular Media Type Filters

The following technologies have demonstrated their ability to meet the performance objectives of Title 22. The "STATUS" designation gives an indication as to which technologies have been given formal Departmental recognition. For projects proposing a technology which is not listed herein or whose "STATUS" is unknown, a review of the proposal should be conducted by the Recycled Water Unit prior to acceptance.

**Dynasand** **Status--Accepted**
**Parkson Corporation**
2727 N.W. 62nd Street
Fort Lauderdale, Florida 33340-8399
(305) 974-6610

Description: Upflow deep bed continuous backwash

Media configuration:

| Media Depth (inches) | Effective Size (mm) | Uniformity Coefficient |
|---|---|---|
| sand: 40 | 1.30 | 1.50 |

Acceptance / Reference:

- -Listed in the CDHS Direct Filtration Guidelines (1988)
- -Conditional acceptance letter dated 12/1/86 from CDHS
- -Conditions of acceptance include: 1) media design specs. as noted above, 2) complete recycling of filter medium every three to four hours.
- -Letter dated 4/23/97 from the San Francisco District Office to the Sewerage Agency of South Marin
- -Memo dated 7/18/97 from Mike Finn (CDHS) re: two performance studies (S.F. Bureau of water Pollution Control and Sewerage Agency of South Marin)

Comments: Classified as direct filtration.

Installations: Sewerage Agency of Southern Marin (Evaluation outlined in a Pilot Test Final Report for the Agency dated June 1989); San Francisco-Bureau of Water Pollution Control has a pilot unit at the Oceanside WWTP, and others.

**WATERLINK SuperSand** **Status--Accepted**
**Waterlink Separations, Inc.**
29850 N. Skokie Hwy. (U.S. 41)
Lake Bluff, Illinois 60044-1192
(847) 473-3700

Description: Upflow deep bed continuous backwash

Media configuration:

| Media Depth (inches) | Effective Size (mm) | Uniformity Coefficient |
|---|---|---|
| sand: 40 | 1.30 | 1.50 |

Acceptance / Reference:

-Conditional acceptance letter dated 1/14/2000 from CDHS.
-Conditions of acceptance include: 1) media design specs. as noted above, 2) complete recycling of filter medium every three to four hours.

-Note: Waterlink holds the patents for the design of the filter approved as the "DynaSand" marketed by Parkson Corp. under licensing agreements. Master file contains all documentation.

Comments: Classified as direct filtration.

Installations: Proposed for Delta Diablo Sanitation District (Pittsburg, CA), Coachella Valley and Escondido.

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**WESTECH TECHNASAND** **Status--Accepted**
**Westech Engineering, Inc.**
3625 South West Temple
Salt Lake City, Utah 84119-0068
(801) 265-1000

Description: Upflow deep bed continuous backwash

Media configuration:

| Media Depth (inches) | Effective Size (mm) | Uniformity Coefficient |
|---|---|---|
| sand: 40 | 1.30 | 1.50 |

Acceptance / Reference:

-Conditional acceptance letter dated 4/5/2002 from CDHS.

-Conditions of acceptance include: 1) media design specs. as noted above, 2) complete recycling of filter medium every three to four hours.

-Note: Mftr. has indicated they will warrant the Technasand Filter to meet Title 22 filtration requirements. Same principle as the Parkson Dynasand. Master file contains all documentation.

Comments: Classified as direct filtration.

Installations: Proposed for Carmel Valley Ranch.

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**Hydro-Clear** **Status--Accepted**
**U.S. Filter**
**Zimpro Environmental, Inc.**
301 W. Military Rd.
Rothschild, WI 54474
(715) 359-7211

Description: Shallow pulsed bed filter

Media configuration:

| Media Depth (inches) | Effective Size (mm) | Uniformity Coefficient |
|---|---|---|
| sand: 10-12 | 0.45 | 1.50 |

Acceptance / Reference:

-Listed in the CDHS Direct Filtration Guidelines (1988)

-Conditional acceptance letter dated 11/17/81 from CDHS.

-Conditions of acceptance include: 1) minimum bed depth of 10-inches of sand with E.S. of 45 mm, 4) at least 6 minutes between pulses and no more than 25 pulses per filter run.

-U.C. Davis Evaluation Report; "Evaluation of the Pulsed-Bed Filter For Wastewater Reclamation in California", 1981.

Comments: Classified as direct filtration

Installations: Moulton Niguel WD, San Luis Obispo, San Clemente, Rancho Murrieta, Fallbrook, and others.

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**Infilco-Degremont, Inc.** **Status--Accepted**
**Automatic Backwash (ABW)**
P. O. Box 71390
Richmond, Va 23255-1390
(804) 756-7697

Description: shallow bed, traveling bridge

Media configuration:

| | Media Depth (inches) | Effective Size (mm) | Uniformity Coefficient |
|---|---|---|---|
| | sand: 11 | 0.55 | 1.50 |

Acceptance / Reference:
- -Listed in the CDHS Direct Filtration Guidelines (1988)
- -U.C. Davis Evaluation Report; "Evaluation of the Enelco ABW Automatic Backwash Filter For Wastewater Reclamation in California", dated November 1988.

Comments: Loading rate limited to 2 gpm/$ft^2$; Max. influent turbidity <10 NTU.

Installations: Sacramento County, Sepulveda Water Reclamation, Folsom WWTP, Victor Valley WWRP, LA City-Tillman WRP, Shasta Lake WWTP, and others.

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**Aqua-Aerobic Systems, Inc.** **Status--Accepted**
**Automatic backwash filter (AquaABF)**
P.O. Box 2026
6306 N. Alpine Road
Rockford, IL 61111
(815) 654-2501

Description: Shallow bed traveling bridge

Media configuration:

| | Media Depth (inches) | Effective Size (mm) | Uniformity Coefficient |
|---|---|---|---|
| | sand: 11 | 0.55 | 1.50 |

Acceptance / Reference:
- -Listed in the CDHS Direct Filtration Guidelines (1988)

-U.C. Davis Evaluation Report entitled "Evaluation of the Aqua-Aerobic Automatic Backwash Filter For Wastewater Reclamation in California" dated July 1986.

Comments: Loading rate limited to 2 gpm/$ft^2$; Max. influent turbidity <10 NTU.

Installations: None known

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**Tetra Technologies, Inc.** **Status--Accepted**
**Tetra-Denit.**
1628 Tiburon Blvd.
Tiburon, CA 94920
(1-800-364-4617)

Description: Tetra Deep Bed-Denitrification Filters

Media configuration:

| | Media Depth (inches) | Effective Size (mm) | Uniformity Coefficient |
|---|---|---|---|
| Silica sand: | 48-72 | 2.2 | 1.35 |

Acceptance / Reference:
-Conditional acceptance letter signed by M. Kiado (CDHS) re: LADWP dated 3/17/92
-Letter dated 10/6/97 from Parsons Engineering Science regarding LA-Glendale Water Reclamation Plant pilot study.

Comments: Mono-media granular sand; 4-6 foot depth; intended for direct filtration with chemical addition.

Installations: City of Los Angeles (Glendale WWTP), Lake Arrowhead CSD, Padre Dam MWD, Scotts Valley WD.

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**Centra-flo**
**Applied Process Technology** **Status--Accepted**
35 Wellington Lane
Conroe, Texas 77304
(409) 539-4099

Description: Centra-flo Gravity Sand Filter
Downflow Continuous Wash Filter

Media configuration:

| | Media Depth (inches) | Effective Size (mm) (graded) | Uniformity Coefficient |
|---|---|---|---|
| | sand: 40 | 0.5 – 3.0 | 1.50 |

Acceptance: CDHS letter dated January 6, 1999 for landscape irrigation

Comments: Pilot testing conducted at Union Sanitary District's Alvarado WWTP (1994); loading rate up to 4.4 GPM/$ft^2$.

Installations: Tejon Ranch Development ‘99 (I-5 @ Tejon Pass)

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**Fluidsand**
**Fluidyne Corporation** **Status--Accepted**
2816 West First Street
Cedar Falls, IA 50613
(319) 266-9967

Description: Fluidyne Fluidsand Filter
Upflow Continuous Backwash Filter

Media configuration:

| | Media Depth (inches) | Effective Size (mm) (graded) | Uniformity Coefficient |
|---|---|---|---|
| silica sand: | 40 | 0.8 – 1.0 | 1.6 |

Acceptance / Reference:
- -Conditional acceptance letter dated 5/03/2000 from CDHS.
- -Conditions of acceptance include: 1) media design specs. as noted above, 2) complete recycling of filter medium every three to four hours.
- -Engineering Report dated June 9, 1997 submitted by Questa Engrg. for the Canada Woods Reclamation Facility.

Comments: Classified as direct filtration. Designed for waters containing TSS up to 20 mg/l (per manufacturer); Performance data submitted by the manufacturer demonstrates this technology’s ability to comply with the turbidity performance standards. Design and operation conceptually similar to Dynasand.

Installations: Tenaya Lodge located in Fish Camp (Evaluated in a "facilities Review" report by Carollo Engineers dated September 1990). Canada Woods Development ('99) in the Monterey area (without SDHS approval). Castanoa Ranch ('99) in San Mateo County.

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**Hydrasand** **Status--Accepted**

**Andritz Ruthner, Inc.**
1010 Commercial Blvd. So.
Arlington, Texas 76017
(817) 465-5611

Description: Upflow, continuous wash filter

Acceptance / References:

-Conditional acceptance letter dated June 23, 2000 from CDHS.

-Conditions of acceptance include: 1) media design specs. as noted above, 2) complete recycling of filter medium every three to four hours.

-Report available entitled “Microbial Assessment of the Lanai Auxiliary Reclamation Facility to Produce Wastewater Effluent for Unrestricted, Non-potable Reuse” dated October 1998.

Comments: Mftr. has indicated they will warrant the Hydrasand Filter to meet Title 22 requirements. Same principle as the Parkson DynaSand.

Installations: None in California (proposed for City of Corona), installed in Trumansburg NY and Lanai City, HI.

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***Volcano*** ***Status—NOT YET ACCEPTED***

Description: Continuous wash downflow sand filter

Acceptance / References:

-Documentation of CDHS approval does not exist. The Recycled Water Unit has no technical data on this process.

Comments: Future proposals for use of this filtration technology will require an acceptability assessment prior to approval.

Installations: Boulder Creek G.C. (Santa Cruz County), Sierra Heights WWTP (Santa Clarita), Carmel Valley WWTP, Shelter Cove (Humbolt)

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## Other Media Type Filters

**Fuzzy Filter**
**Schreiber LLC** **Status--Accepted**
100 Schreiber Drive
Trussville, Alabama 35173

Description: "Fuzzy Filter"-compressible plastic filter media
Upflow design

Media configuration:

| | Media Depth (inches) | Effective Size (mm) | Uniformity Coefficient |
|---|---|---|---|
| Synthetic: Plastic | 30 (variable) | (1.25") | 1.50 |

Media is quasi spherical, highly porous and compressible

Acceptance / Reference:
-Conditional acceptance letter date February 24, 2003 from CDHS.
-Conditions of acceptance include: 1) media design specs. as noted above, 2) filtration rate not to exceed 30 gpm/$ft^2$, 3) all Title 22 installations shall have design changes as outlined by Schreiber in correspondence dated January 21, 2003 (i.e. - backwash with filtered water, wash outlet below filtered outlet, valving position alarms), 4) individual operations plans shall include recommended operational configurations (i.e. percent compression and loading rate) based on secondary quality.
-Evaluated by U.C. Davis (Report dated September 1996)

Comments: Evaluated at loading rates up to 30 GPM/$ft^2$; media configuration/porosity/depth varies based on percent compression; water passes through media rather than around media.

Installations: City of Yountville

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## Membrane Technologies

**ZENON**
**Zenon Environmental Services, Inc.**
3239 Dundas Street West
Oakville, Ontario  L6M 4B2
(905) 465-3030

**Cycle-Let (Thetford)** **Status--Accepted**

Description:  Membrane (“Ultra") filtration (originally marketed as Thetford Cycle-Let); complete package unit including pretreatment, biological oxidation, membrane ultra-filtration, GAC and U.V.

Acceptance / References:

-CDHS acceptance memorandum to LARWQCB dated November 12, 1993 regarding the Water Gardens Project.

-Report entitled "Evaluation of the Thetford Cycle-Let Reclamation System's Ability to Meet Title 22, prepared by Engineering-Science, dated August 1991.

-Report entitled "Thetford Systems Inc. Cycle-Let Wastewater Treatment and Recycling System – Water Garden Project, Santa Monica, CA" dated July 1993 prepared by CDM

Comments: Membrane approved has average pore size of .005 micron.

Installations: "Water Gardens" (Santa Monica), Sony Music Campus (Santa Monica).

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**ZeeWeed / Zenogem** **Status--Accepted**

Description: Variant of the Cycle-Let, OCP Bio-reactor / Microfiltration process

Acceptance / References:

-Conditional acceptance letter from CDHS dated August 12, 1999

-Draft Final Report “California DHS Certification Testing-for Zenon (ZeeWeed) Membrane” prepared by Montgomery Watson (1/8/99).

Comments: Approval based on use of the "OCP" membranes only. Conditions of approval include: membrane integrity tests required; max. flux of 49.8 GFD.

Installations: Unknown

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**ZeeWeed 1000 UF** **Status--Accepted**

Description: Submerged Hollow Fiber Ultrafiltration Membrane

Acceptance / References:

- -Conditional acceptance letter from CDHS for T-22 compliance dated October 12, 2001
- -Report entitled “California Department of Health Services Certification Testing For Zenon ZeeWeed 1000 Membrane”, prepared by Montgomery Watson (June 2001). This report was prepared for demonstrating compliance with the California Surface Water Treatment Rule.

Comments: Approval based on use of the hollow fiber polymer “ZeeWeed 1000 UF Membrane” with a 0.02 micron nominal pore size. Conditions of approval include: max. flux of 30 GFD; max. TMP of -10 psi; membrane integrity tests required.

Installations: Unknown

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**U. S. Filter / MEMCOR** **STATUS--Accepted**
4116 Sorrento Valley Blvd.
San Diego, CA 92121
(619) 445-0578

**Memcor Continuous Microfiltration (CMF)**

Description: 0.2 micron *Polypropylene* Hollow Fiber Micro-Filtration - Pressure Filtration

Acceptance / References:

- -Conditional acceptance letter from CDHS dated 1/10/2000
- -Approved under the SWTR using 0.2 micron membrane.

Comments: Flux rate not to exceed 0.5 gpm/$m^2$, transmembrane pressure not to exceed 18 PSI, membrane integrity tests required.

Installations: West Basin MWD, Orange County Water District, City of Livermore, Dublin/San Ramon SD

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**Memcor Continuous Microfiltration (CMF)**

Description: 0.1 micron *Polyvinylidene Fluoride* (PVDF) Hollow Fiber Micro-Filtration - Pressure Filtration

Acceptance / References:
- -Conditional acceptance letter from CDHS dated 1/10/2000
- -Approved under the SWTR using 0.2 micron membrane.

Comments: Flux rate not to exceed 0.5 gpm/$m^2$, transmembrane pressure not to exceed 18 PSI, membrane integrity tests required.

Installations: West Basin MWD, Orange County Water District, City of Livermore, Dublin/San Ramon SD

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**Memcor Continuous Microfiltration Submerged (CMF-S)**

Description: 0.2 micron *Polypropylene* Hollow Fiber Micro-Filtration – Submerged/Vacuum Filtration

Acceptance / References:
- -Conditional acceptance letter from CDHS dated 1/10/2000

Comments: Flux rate not to exceed 0.5 gpm/$m^2$, transmembrane pressure not to exceed 18 PSI, membrane integrity tests required.

Installations: Unknown

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**Memcor Continuous Microfiltration Submerged (CMF-S)**

Description: 0.1 micron *Polyvinylidene Fluoride* (PVDF) Hollow Fiber Micro-Filtration – Submerged/Vacuum Filtration

Acceptance / References:

-Conditional acceptance letter from CDHS dated 1/10/2000

Comments: Flux rate not to exceed 0.5 gpm/$m^2$, transmembrane pressure not to exceed 18 PSI, membrane integrity tests required.

Installations: Unknown

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**U. S. Filter/Jet Tech Products-Memjet$^{tm}$** **STATUS--Accepted**
1051 Blake
Edwardsville, KS 66111

Description: 0.1 micron *Polyvinylidene Fluoride* (PVDF) Hollow Fiber Micro-Filtration – SBR/Vacuum Filtration

Acceptance / References:
-Conditional acceptance letter from CDHS dated 10/7/2002

Comments: Flux rate not to exceed 25 gfd, transmembrane pressure not to exceed 7.2 PSI, membrane integrity tests required.

Installations: Unknown

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**PALL Corporation** **STATUS -- Accepted**
25 Harbor Park Drive
Port Washington, NY 11050 USA
(516) 484-3600

Description: PVDF Hollow Fiber Microza Microfiltration 0.1 micron (P/N XUSV-5203

Acceptance / References:
-Conditional acceptance letter from CDHS dated 1/10/2000
-Approved for compliance under the SWTR base on report entitled “California Department of Health Services Certification Testing for Pall (Microza) Microfiltration Membrane” prepared by Montgomery-Watson (July 1999).
-Performance study conducted at OCWD Water Factory 21 (SLS Report 7725) “Long-Term Testing of Pall Microza 0.1 um MF System on Secondary Effluent at Water Factory 21, Fountain Valley, CA” (September 23, 1998).

Comments: Flux rate not to exceed 32 GFD, transmembrane pressure not to exceed 25 PSI, membrane integrity tests required.

Installations: Unknown

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**MITSUBISHI**
**Mitsubishi International Corp.** **STATUS -- Accepted**
333 South Hope Street West, Suite 2500
Los Angeles, CA 90071

Description: Mitsubishi Membrane Bioreactor (MBR)
Sterapore HF 0.4 micron hollow fiber polyethylene

Acceptance / References:
-Conditional acceptance letter from CDHS dated April 23, 2001
-Report entitled "Assessing the Ability of Membrane Bioreactor to Meet Existing Water Reuse Criteria (Mitsubishi Rayon Co., Ltd.)" prepared by Montgomery-Watson (March 2001).

Comments: Flux rate not to exceed 13 GFD; max. operating pressure of –5.8 psi; membrane integrity tests required.

Installations: Unknown

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**KUBOTA** **STATUS -- Accepted**

Description: Kubota Membrane Bioreactor (MBR); Type 510 0.4 micron chlorinated polyethylene flat sheet membrane

Acceptance / References:
-Conditional acceptance letter from CDHS dated March 18, 2003
-Report entitled "Assessing the Ability of the Kubota Membrane Bioreactor to Meet Existing Water Reuse Criteria" prepared by Montgomery-Watson-Harza (February 2003).

Comments: Flux rate not to exceed 20 GFD; max. operating vacuum pressure of <3.0 psi; membrane integrity tests required; turbidity performance limited to Section 60301.320 (b) of the Water Recycling Criteria.

Installations: Unknown

## Cloth Filter Technologies

**AQUA AEROBIC Systems, Inc.** **Status--Accepted**
6306 N. Alpine Rd.
Rockford, IL 61130-0026
(815) 654-2501

Description: **Submerged Cloth-Media Rotating Disk Filter (Utilizing the 102 needle felt fabric)**

Acceptance / References:
-Conditional acceptance letter from CDHS dated June 29, 2001
-Report entitled "Evaluation of the Aqua-Aerobic Systems Cloth-Media Disk Filter (CMDF) for Wastewater Recycling Applications in California" prepared by UC Davis (March 2001).
-Report entitled "Evaluation of Aqua-Aerobics Systems AquaDisk Filter Technology at Orange County Water District, Fountain Valley, California" (February 25, 2000).

Comments: Utilizes the "102 needle felt fabric", operates under vacuum. Conditions of acceptance: loading rate not to exceed 6 $gpm/ft^2$; technology must be complimented with a disinfection process capable of achieving 5-log virus inactivation in accordance with Section 60301.230 (T-22); acceptance limited to the random woven NF-102 needle felt cloth media having openings ranging from 10 to 30 microns and a thickness of 3.8 mm; influent turbidity not exceed 10 NTU more than 5-percent of the time within a 24-hour period; Operations plan shall specify minimum FTW cycle following high pressure wash based on displacement of two filtrate volumes and effluent turbidity below 2 NTU; scheduled inspections of cloth conditions; ensure adequate sludge wasting; Turbidity performance limited to Section 60301.320(a) of the Water Recycling Criteria.

Installations: None known

Description: **Submerged Cloth-Media Rotating Disk Filter (Utilizing the PA-13 nylon pile fabric)**

Acceptance / References:
-Conditional acceptance letter from CDHS dated May 6, 2002)

-Report entitled "Use of PA-13 Pile Fabric, Supplement to: Evaluation of the Aqua-Aerobic Systems Cloth-Media Disk Filter (CMDF) for Wastewater Recycling Applications in California" prepared by UC Davis (February 2002).

Comments: Utilizes the "PA-13 nylon pile fabric", operates under vacuum. Conditions of acceptance: loading rate not to exceed 6 $gpm/ft^2$; technology must be complimented with a disinfection process capable of achieving 5-log virus inactivation in accordance with Section 60301.230 (T-22); acceptance limited to the PA-13 nylon pile fabric (as tested); influent turbidity not exceed 10 NTU more than 5-percent of the time within a 24-hour period; scheduled inspections of cloth conditions; ensure adequate sludge wasting; turbidity performance limited to Section 60301.320(a) of the Water Recycling Criteria.

Installations: None known

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## 4. DISINFECTION TECHNOLOGIES

Gaseous chlorine or hypochlorite is the most commonly used disinfectant, however alternative technologies are recognized as being acceptable. On-site chlorine generators are also available for industry use.

**ULTRAVIOLET**

**Trojan Technologies, Inc.**
3020 Gore Rd.
London, Ontario Canada N5V 4T7

Description: UV 4000 (Medium Pressure) **Status—Accepted***
UV 3000 (Low Pressure/Low Intensity) " **

Acceptance/References:
-Conditional acceptance letter from CDHS dated September 8, 1995 for UV4000.
-"Trojan System UV4000 UV Disinfection Pilot Study. Riverside, California", May 1995
-"Equivalency of the Trojan System UV4000 and System UV3000 in Meeting California Wastewater Reclamation Criteria at Pacifica, California", June 1994
-"Technical Review: Ultraviolet Disinfection of Wastewater to California Wastewater Reclamation Criteria (Title 22,

Division 4, Chapter 3, of the California Code of Regulations) Using Trojan Technologies' System UV4000 (High Intensity UV Lamp Technology", August 1995.

Comments: Acceptance for the UV4000 conditioned on 1) continuous monitoring/recording of filter effluent turbidity (pre UV), daily coliform monitoring (disinfected effluent) and 3) provide UV dose of at least 100 mW-sec/$cm^2$ under worst operating conditions at peak daily instantaneous flow with a minimum of three banks in operation and a UV dose of at least 140 mW-sec/cm2 with a minimum of four banks in operation, subject to all of the conditions indicated in the NWRI Guidelines.

Installations: City of Pacifica, City of Vallejo, Central Contra Costa S.D., City of Corona, City of San Diego (South Bay WRF), Western Riverside RWF, Olivenhain WD, City of Santa Rosa

***Acceptance granted under the outdated 1993 NWRI Guidelines. Compliance with the NWRI/AWWARF Guidelines has not been demonstrated**

****Acceptance granted under the December 2000 NWRI/AWWARF Guidelines.**

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**PCI-Wedeco Environmental Technologies, Inc. Status—Accepted***
One Fairfield Crescent
West Caldwell, NJ 07006

**-Specktrotherm 33-TAK UV**

Description: (Low pressure/High Intensity)

Acceptance/References
- -Conditional acceptance letter dated 3-31-98 from CDHS and follow-up letter dated 5/21/99 transferring approval from Aquafine to Wedeco).
- -Tested at OCWD as the AWES-Spectrotherm TAK UV System

Comments: Currently marketed as the PCI-Wedeco Spectrotherm 33 TAK UV System. Requires UV dose of 160 mWs/$cm^2$ at max. week flow, 120 mWs/$cm^2$ at peak flow (max. day), and an average of $\geq$160 mWs/$cm^2$ and conform to NWRI Guidelines.

Installations: Leucadia CWD(proposed)

***Acceptance granted under the outdated 1993 NWRI Guidelines. Compliance with the NWRI/AWWARF Guidelines has not been demonstrated**

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**Wedeco - Ideal Horizons LCI-20L Status—Accepted***

Description: (Low pressure/High Intensity)
Model LCI-20L

Acceptance/ References

-Conditional acceptance letter from CDHS dated 2-23-99 for Tejon Ranch.
-Report entitled "Ultraviolet Dose Bioassay of the Ideal Horizons Horizontal Lamp Disinfection System" by HydroQual, Inc. (September 1998).

Comments:

Installations: Tejon Ranch Development (I-5 @ Tejon Pass)

***Acceptance granted under the outdated 1993 NWRI Guidelines. Compliance with the NWRI/AWWARF Guidelines has not been demonstrated**

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**Wedeco - Ideal Horizons TAK 55 Status—Accepted****

Description: (Low pressure/High Intensity/open channel)
TAK 55

Acceptance/References
-Conditional acceptance letter dated 12-4-01 from CDHS.
-Report entitled "Wedeco-Ideal Horizons Low-Pressure, High Intensity Ultraviolet Disinfection System Pilot Study at Orange County Water District" by CH2M Hill (November 2000)

Comments:

Installations: Unknown

****Acceptance granted under the December 2000 NWRI/AWWARF Guidelines.**

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**Aquionics** **Status—Accepted***

**Aquionics, Inc.**
21 Kenton Lands Rd.
Erlanger, Ky 41018

Description: (Medium Pressure/In-line)

Acceptance/Reference:
- -Conditional acceptance letter dated 2-28-00 from CDHS.
- -CH2M Hill, "Aquionics Medium Pressure, High-Intensity Ultraviolet Disinfection System Pilot Study at Orange County Water District" by CH2M Hill (May 1999)

Comments:

Installations: Unknown

***Acceptance granted under the outdated 1993 NWRI Guidelines. Compliance with the NWRI/AWWARF Guidelines has not been demonstrated**

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**Service Systems International, Ltd.** **Status—Accepted***

2800 Ingleton Avenue
Burnaby, B.C. Canada, V5C 6G7

**ULTRAGUARD UV System**

Description: (Open Channel/Low Pressure/High Intensity/vert. lamp)

Acceptance/Reference:
- -Conditional acceptance letter dated 2-1-00 from CDHS.
- -Report: Chen, C. L.; El Jacj, Z; Kuo, J., UV Inactivation of Bacteria and Coliphages in Tertiary Effluent Using Low-Pressure High-Intensity Lamps, November 18, 1999, County Sanitation Districts of Los Angeles County.

Comments:

Installations: Unknown

***Acceptance granted under the outdated 1993 NWRI Guidelines. Compliance with the NWRI/AWWARF Guidelines has not been demonstrated**

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**Aquaray**
**Infilco-Degremont**
2924 Emerywood Parkway
P.O. Box 71390
Richmond, VA 23255-1390

**Aquaray 40 VLS** **Status—Accepted***

Description: Vertical lamp/low Pressure/low intensity

Acceptance: Conditional acceptance letter dated 10/24/97 from CDHS

Comments: Evaluation memo dated 4/30/97 from SDHS concerning transmittance restriction be set at >55%.

Installations: Scotts Valley, Town of Windsor, Dublin/San Ramon CSD

***Acceptance granted under the outdated 1993 NWRI Guidelines. Compliance with the NWRI/AWWARF Guidelines has not been demonstrated**

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**UltraTech Systems**
15 Kay Fries Drive
Stoneypoint, NY 10980

**Terminator** **Status—Accepted***

Description: Vertical/Low Pressure/Low Intensity

Acceptance/References
- -Conditional acceptance letter dated October 23, 2000 from CDHS
- -Report entitled “Ultraviolet Dose Bioassay of the Ultratech Systems Vertical Lamp Disinfection System (65% Transmittance)” by HydroQual, Inc. (February 2000).

Comments:

Installations: Unknown

***Acceptance granted under the outdated 1993 NWRI Guidelines. Compliance with the NWRI/AWWARF Guidelines has not been demonstrated**

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See Appendix A

Alt. Tech. disk – Recycle water Technology listing3-03.doc

# APPENDIX A

## Recognized Filtration and Disinfection Technologies for Recycled Water

### CALIFORNIA DEPARTMENT OF HEALTH SERVICES REDUCTION OF VIRUS AND BACTERIA BY FILTRATION AND DISINFECTION (October 2001)

Title 22 of the California Code of Regulations (Recycled Water Criteria) require extensive treatment of wastewater that is to be used for irrigation of parks and playgrounds or for spray irrigation of food crops. Recycled water for such irrigation is to be oxidized, filtered, and disinfected. Section 60301.320 defines filtered wastewater and Section 60301.230 defines disinfected tertiary recycled water. Additionally, Section 60320.5 allows for "other methods of treatment" provided they are found acceptable to the Department.

Treatment equivalent to that stipulated in sections 60301.320 and 60301.230 is prescribed to greatly reduce the concentration of viable enteric viruses in wastewater. Such a reduction makes it very unlikely that a person would contaminate his hands with a virus when touching a surface wet with reclaimed water. Enteric viruses are excreted by individuals with an intestinal virus infection. They can cause incapacitating disease states in susceptible persons. Those disease states include meningitis, hepatitis, and others.

Capability of Treatment That Sections 60301.320 and 60301.230 Cite

The County Sanitation Districts of Los Angeles County (CSDLAC, 1977) determined the capability of treatment that sections 60301.320 and 60301.230 cite, to reduce the concentration of viable virus in activated sludge effluent. CSDLAC added laboratory-cultured poliovirus and 150 milligrams of alum coagulant per liter of the activated sludge effluent and passed it through pilot-scale treatment facilities comprised of a clarifier and a sand filter to meet the turbidity limits that section 60301.320 cites in the definition of filtered wastewater: turbidity shall not exceed 2 turbidity units as a daily average and shall not exceed 5 turbidity units more than five percent of the time. Filter effluent was chlorinated in a chamber with a two-hour theoretical contact period and a 90-minute actual, modal contact period.

Such treatment reduced the concentration of virus plaque-forming units to 1/100,000$^{th}$ of the concentration in wastewater upstream from the filter, when the chlorine residual was at least 5 milligrams per liter and at least sufficient to reduce the concentration of total coliform bacteria to less than 2 per hundred milliliters. Sections 60301.320 and 60301.230 require that disinfection shall limit the concentrations of total coliform bacteria in the effluent so that the median of consecutive daily samples does not exceed 2.2 per hundred milliliters, as determined from the bacteriological results of the last seven days for which analyses have been completed.

Equivalent Treatment By Granular Media Bed Filtration and Disinfection

Section 60320.5 of Title 22 allows the regulatory agency to accept processes other than those that Sections 60301.320 and 60301.230 cite if the applicant demonstrates to the satisfaction of DHS that the other processes will assure an equal degree of treatment. DHS deems other treatment equivalent to that cited in sections 60301.320 and 60301.230 when: (1) a proponent demonstrates that the proposed alternative treatment consistently reduces the concentration of viable virus to a level 1/100,000$^{th}$ of the concentration of seeded virus in influent to the filter; and (2) the proponent will provide reliability features equivalent to those that Title 22 cites, and will comply with all other applicable stipulations of Title 22.

Past demonstrations are sufficient to allow DHS to accept the combination of granular media bed filtration and disinfection of oxidized wastewater as equivalent to treatment that sections 60301.320 and 60301.230 cite, when the following four conditions are obtained:

(1) coagulant is added when the turbidity of the oxidized wastewater (i.e. secondary effluent) exceeds 5 NTU for more than 15 minutes (or exceeds 10 NTU at any time) upstream from the filter;

(2) the turbidity of filter effluent does not exceed a daily average of 2 NTU, 5 NTU more than 5 percent of the time, and 10 NTU at any time;

(3) the concentration of viable total coliform bacteria in the final effluent does not exceed 2.2 per hundred milliliters as a median in samples taken in seven consecutive days, and does not exceed 23 per hundred milliliters in more than one sample in a 30-day period; and

(4) the disinfection process complies with (a) or (b) below:

(a) if chlorination is used it provides a CT (chlorine concentration times modal contact time) value not less than 450 milligram-minutes per liter at all times with a modal contact time at least 90 minutes at the peak daily flow rate; or

(b) if ultraviolet light irradiation is used, the design and operation of the UV light disinfection process complies with the stipulations of the NWRI/AWWARF document cited below under the heading References Cited.

Demonstration With Other Filtration and Disinfection Processes

The particle size distribution (PSD) of secondary sewage treatment effluent filtered by a membrane, cloth, or similar medium will differ significantly from that of effluent of a granular media bed filter, insofar as PSD affects the effectiveness of the downstream disinfection process. The term "size distribution" refers to the number of particles per milliliter in each of several specific ranges of sizes. Polycarbonate membrane laboratory filters with pore sizes of 12, 8, 5, 3, 1, and 0.1 micron can be used (Levine, et al., 1985; NCC, 1984), with minimal equipment requirements. A particle counter can be used to determine PSD for the following size ranges, in microns: 1.2 to 2, 2 to 5, 5 to 10, 10 to 20, 20 to 50, 50 to 100, 100 to 200, and larger than 200 (Stahl et al., 1994).

If a filter other than a granular media bed filter is proposed to be used and the use of reclaimed water requires equivalence with treatment that section 60301.320 or 60301.230 cites, the proponent must undertake a demonstration to show DHS what operating conditions guarantee that the filter and disinfection process will consistently reduce the concentration of virus to 1/100,000$^{th}$ of the virus concentration in wastewater upstream from the filter and limit the concentration of total coliform bacteria to comply with concentrations that sections 60303 and 60313(b) cite. The demonstration will involve operation of the filter and disinfection process under the following conditions:

- the filter receives the type of wastewater from which recycled water is proposed to be produced;

- the range of qualities of wastewater received by the filter includes qualities that are expected to occur when recycled water is produced, and are the most challenging to the

effectiveness of the filter and disinfection process (e.g., concentration of suspended solids is at the maximum);

- laboratory-grown viruses are added to the wastewater upstream from the filter;

- samples are taken upstream from the filter and downstream from the disinfection process for determination of numbers of plaque-forming units of virus per volume of sample;

- samples are taken of wastewater upstream and immediately downstream from the filter for determination of concentration of total suspended solids;

- turbidity of the filter effluent is continuously measured by a continuous recording turbidimeter;

- samples of disinfected effluent are taken for determination of the concentration of total coliform bacteria;

- additionally if disinfection is by chlorination, samples are taken of wastewater upstream from the filter for determination of concentration of ammonia and samples of disinfected effluent are taken for determination of concentration of chlorine residual;

- additionally if disinfection is by UV irradiation, fluid transmittance at 254 nm (% T) and flow rate of filter effluent are continuously measured and recorded;

- The greatest appropriate time between backwashes, or other actions that renew filter yield or efficacy, is determined by experiment, with turbidity of filter effluent allowed to range as high as needed for economically practicable treatment (but not to exceed 2 NTU as a daily average, 5 NTU more than 5 percent of the time, or 10 NTU at any time); and

A test run is comprised of one continuous operation between two consecutive backwashes (or other actions that renew filter yield or efficacy). A demonstration shall have at least three test runs during which the quality and/or flow rate of influent to the filter is most challenging for the disinfection process.

Qualities most challenging to UV disinfection might include high concentration of suspended solids, high turbidity and low transmittance. Qualities most challenging to chlorine disinfection might include high concentration of suspended solids, high turbidity and high chlorine demand.

If the proponent wants to propose a CT value or minimum chlorine contact time that differs from that cited above under the heading Equivalent Treatment By Granular Media Bed Filtration and Disinfection, or a UV dose that differs from what the NWRI/AWWARF Guidelines cite, the proponent shall perform as many test runes as necessary to construct a dose-response curve for virus reduction. The curve shall show the required value(s) of such parameters at which the concentration of viable viruses in the disinfected effluent is reduced to 1/100,000$^{TH}$ of the concentration in the influent to the filter.

During each test run, viruses shall be added to wastewater in numbers sufficient to determine whether the concentration in disinfected effluent is less than 1/100,000$^{th}$ of the concentration in wastewater upstream from the filter. The viruses added to wastewater upstream from the filter shall be F-specific bacteriophage MS2, polio virus, or other virus that is at least as resistant to disinfection as polio virus. F-specific bacteriophage MS2 is a strain of a specific type of virus that infects coliform bacteria that is traceable to the American Type Culture Collection (ATCC 15597B1) and is grown on lawns of E. coli (ATCC 15597). Chlorine residual in samples of chlorinated effluent taken for determination of concentrations of virus plaque-forming units and total coliform bacteria shall be neutralized with a reducing agent approved by DHS, when those samples are taken.

The proponent shall submit to DHS a proposed protocol for all work to be undertaken in the demonstration. The proponent will undertake the demonstration only pursuant to a protocol DHS has approved.

The demonstration must identify operating conditions that consistently achieve that virus reduction and compliance with the above-cited limits on the concentration of total coliform bacteria. The regulatory agency will cite those operating conditions and will stipulate that they will be maintained.

The combination of a filtration process and a separate disinfection process provides multiple barriers to limit the concentration of viable viruses somewhat when the other malfunctions. DHS will not accept filtration alone, or disinfection alone, as complying with Title 22.

**REFERENCES CITED**

Levine, A.D., Tchobanoglous, G., and Asano, T., “characterization of the Size Distribution of Contaminants in Wastewater: Treatment and Reuse Implications,” Journal Water Pollution Control Federation, July 1985, pages 805-816.

NCC (Nuclepore Corporation Catalog), “Innovations in Membrane Filtration,” Pleasanton, California, 1984.

National Water Research Institute / American Waterworks Association Research Foundation), Ultraviolet Disinfection Guidelines for Drinking Water and Water Reuse, December 2000. That document is available for purchase from National Water Research Institute, P.O. Box 20865, Fountain Valley, CA 92728-0865, telephone (714) 378-3278.

Stahl, J.F., Kuo, J.F., Chen, C., and Horvath, R.W., “Evaluation of Four Different Tertiary Filtration Plants for Turbidity Control”, presented at 65th Annual Conference of Water Environment Federation, September 20-24, 1992, New Orleans (paper published in November/December 1994 issue of the Journal of the Water Environment Federation).